Precision Horticulture: Technology Development and Research and Management Applications

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Objectives:
The goal of this project was to develop the harvesting machinery, and initiate statistical and mapping methodologies to allow growers to view and interpret the annual productivity of each tree in their orchards. The overall goal of this activity is to provide the information needed to optimize fertilization strategies and to improve on-farm research capability.

Executive Summary:

In a preceding CDFA funded study by the principle investigator of this grant, it was clearly demonstrated that yield is the primary determinant of nutrient demand and uptake efficiency and therefore, fertilizer needs. In tree crops it is recognized, however, that yields vary dramatically from tree to tree within an orchard and between orchards therefore making accurate fertilizer recommendations impossible. Given this fundamental limitation it has been impossible to develop truly efficient orchard fertilizer management systems or to conduct nutritional research experiments properly.

Based upon this earlier work, it was theorized that the ability to map yield of each tree in an orchard and to use that information to optimize inputs and directly contribute to improved resource use efficiency. The benefits to in-field experimentation would be equally significant. The most direct benefit of this information would be the ability to optimize fertilization strategies on a site-specific basis. To achieve this goal this project aimed to develop the means to rapidly harvest and map Pistachio tree yields in commercial orchards on a tree by tree basis by integrating tree location protocols and yield monitors into the harvesting machinery and to develop the statistical and visual computational methodology to analyze and map results. To help determine the cause of yield variability soil and plant tissue samples were collected and remote sensed data was collected and contrasted with yield data.

A majority of the originally designed tasks and objectives have been achieved. In 2002 we successfully tested a new instrument that allowed us to attain the yields of every tree in a 6040 tree orchard accurately and without substantially slowing normal harvest times. In 2003, the experiment was extended to cover the original 6,040 trees harvested in 2002 and an additional 6,200 for a total of 12,240 individual yield data points. Yield maps, plant nutrient maps, soil maps and remote sensed spectral analysis, were generated and

contrasted with yield maps to provide an initial determination of the causes of yield variability and propose changes in management practice. Several critical observations can be drawn from this data. Three years of results demonstrate a great deal of variability across the orchard and from tree to tree within each orchard row. This unexpectedly large variation (in an orchard which was thought to be relatively uniform), indicates how greatly tree variability has been underestimated. This has several consequences, firstly it suggests that management practices should not be applied uniformly across large areas of orchards as they are now, but rather must be optimized at a far more local scale. Secondly, it demonstrates that the full yield potential of Pistachio is as high as 9,000 lbs in-shell split (acre equivalent/year) which is almost twice as high as previously accepted.

In an attempt to determine the cause of yield variability in this orchard, a series of 10,000 individual soil and plant samples were collected and analyzed for nutrients (soil and plant) and physical characteristics (soil). This data was supplemented with remote sensed analysis of leaf temperature, vegetation index, multi- spectral analysis and chlorophyll index. While clear trends and correlations between yield and several variables it has not been possible to clearly associate yield variability with any single variable.

Engineering and statistical challenges remain and this project will be continued for 2 additional years with private funding.